

# GIS-Based Infrastructure Modeling

Hydrogen Scenario Meeting

August 9-10, 2006

Keith Parks, NREL

# GIS-Based Infrastructure Modeling

- Station Analysis
  - Selection Criteria
  - Los Angeles
    - By 2015 (10 & 20 Station Layouts)
    - By 2025 (100 & 600 Station Layouts)
  - NYC
    - Early Infrastructure (20 stations) Comparison
- Station Layouts (SMR, Liquid, Pipeline)
- Delivery Discussion

# Station Selection Criteria

- Consumer strategy attributes rated good and above
- Proximal to major civic airports
- Within 2 mile from a road with traffic above 200,000 vehicles per day
- Within 2 miles of a retail center
- Within a Census tract with 3000 and more registered vehicles (above average vehicle population)
- Accessible by major and secondary roads
- Balanced coverage

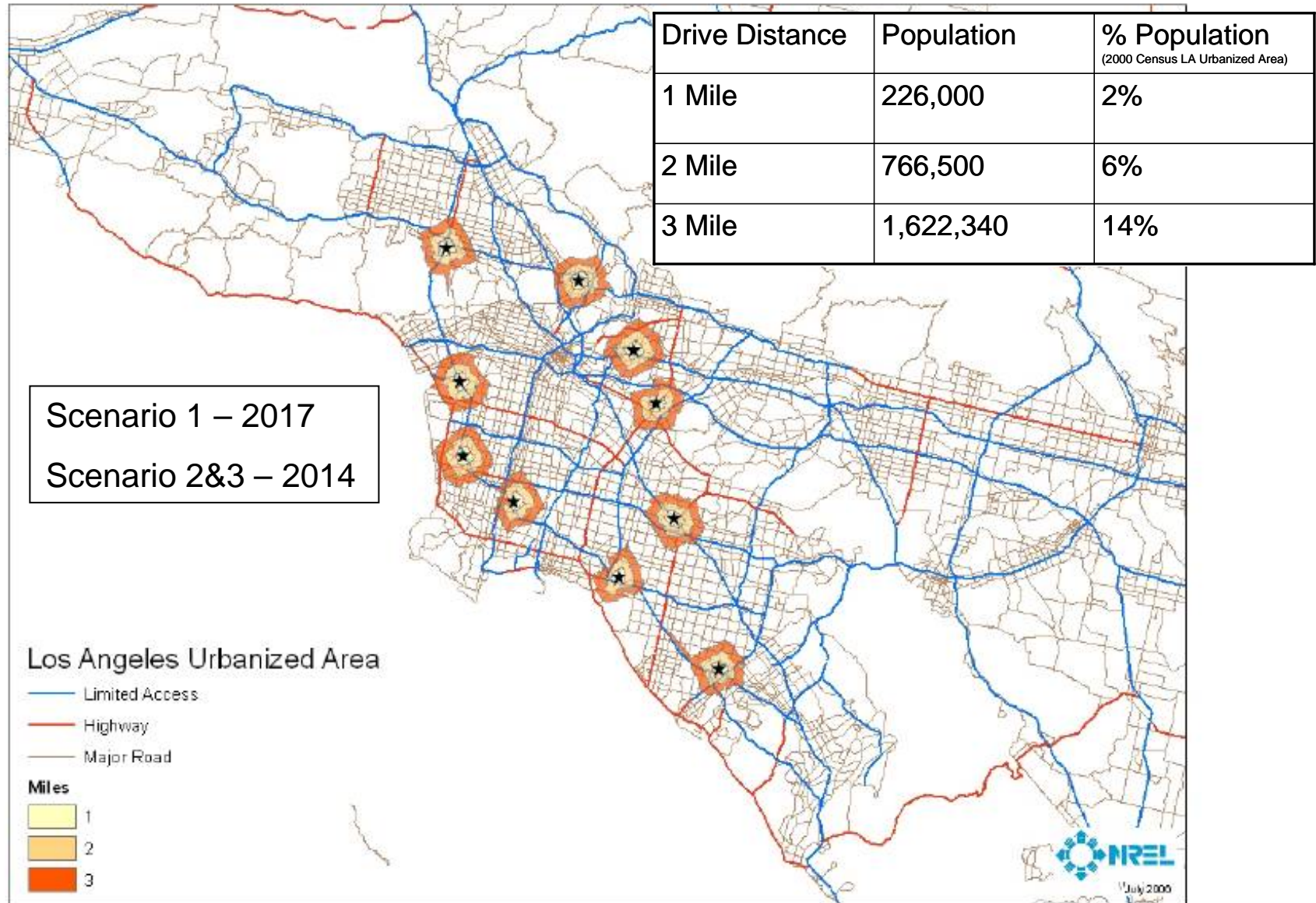
## Los Angeles Urbanized Area

- Los Angeles Urbanized Area
- Limited Access
- Highway
- AADT above 200,000 vehicles
- Gasoline Stations with 'good', 'high', and 'very high' demand
- Retail Centers
- Census tracts with 3000 and more registered vehicles



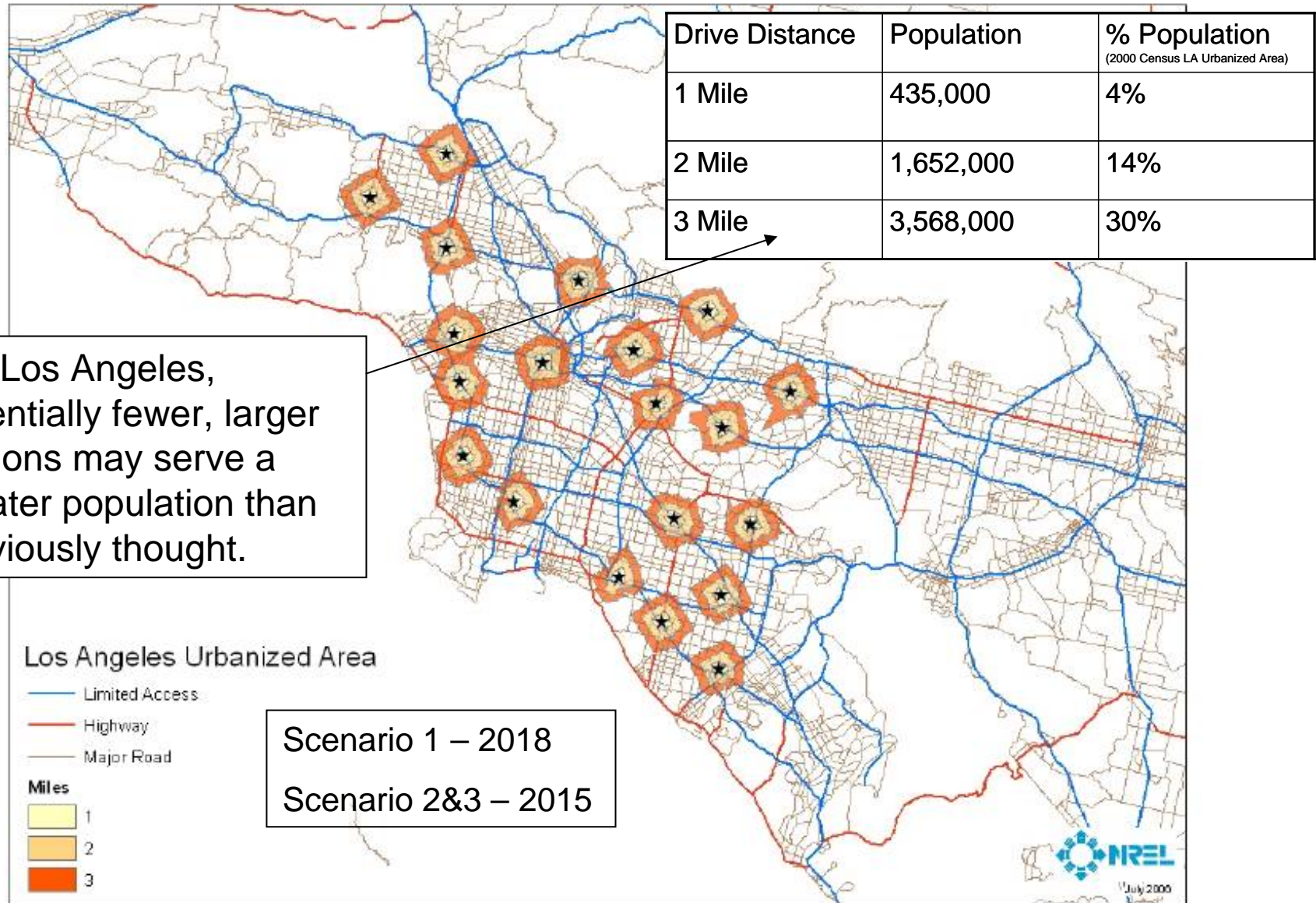
June 2000

# Lighthouse Validation - 10 Stations

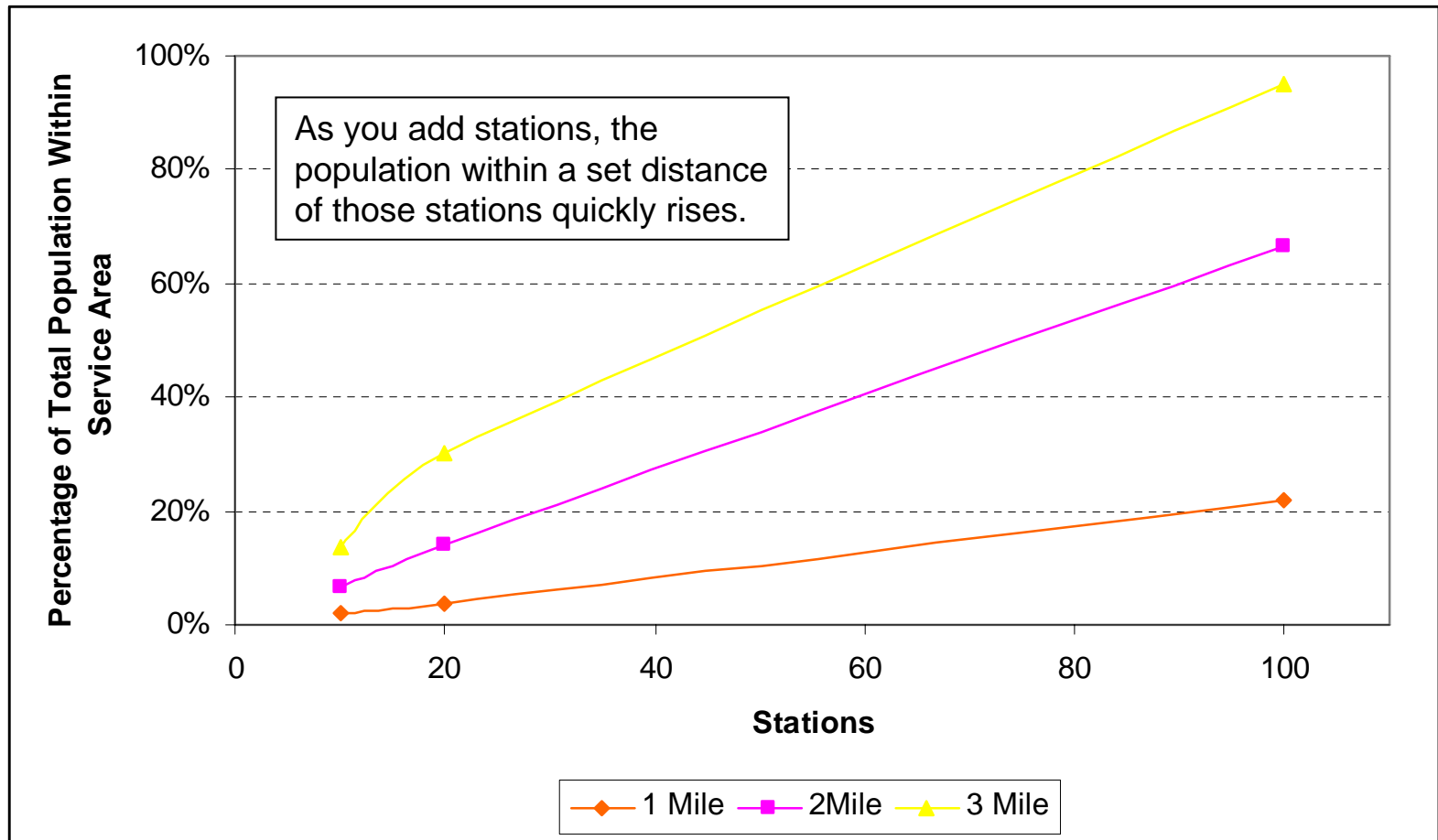




# Lighthouse Validation - 20 Stations



# Service Area Quickly Saturates the LA Basin Population



# Deploy 100 Stations in LA Basin and Implement Regional Infrastructure





# A Closer Look at 100 Stations in LA Basin



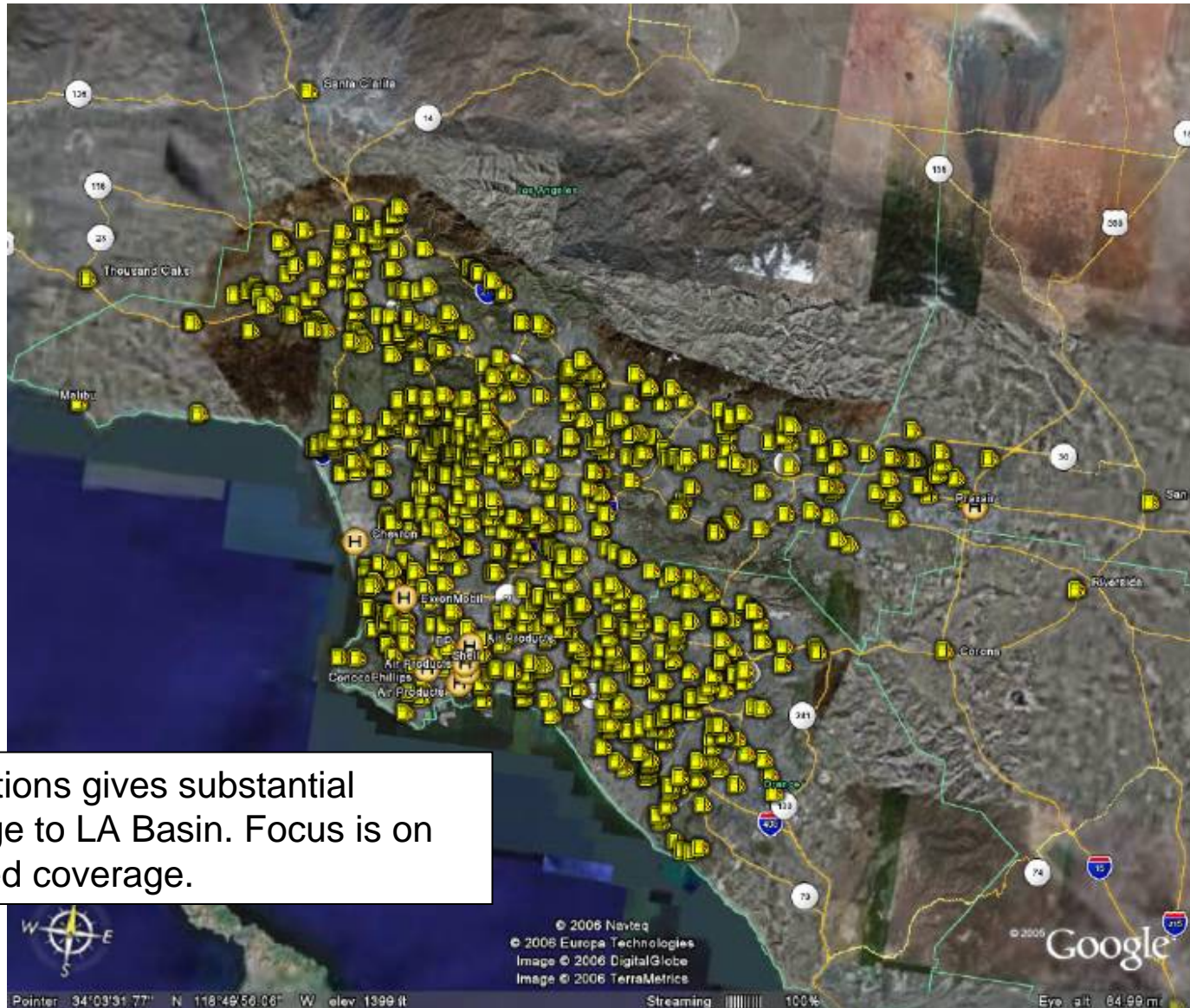
# Regional – 600 Stations



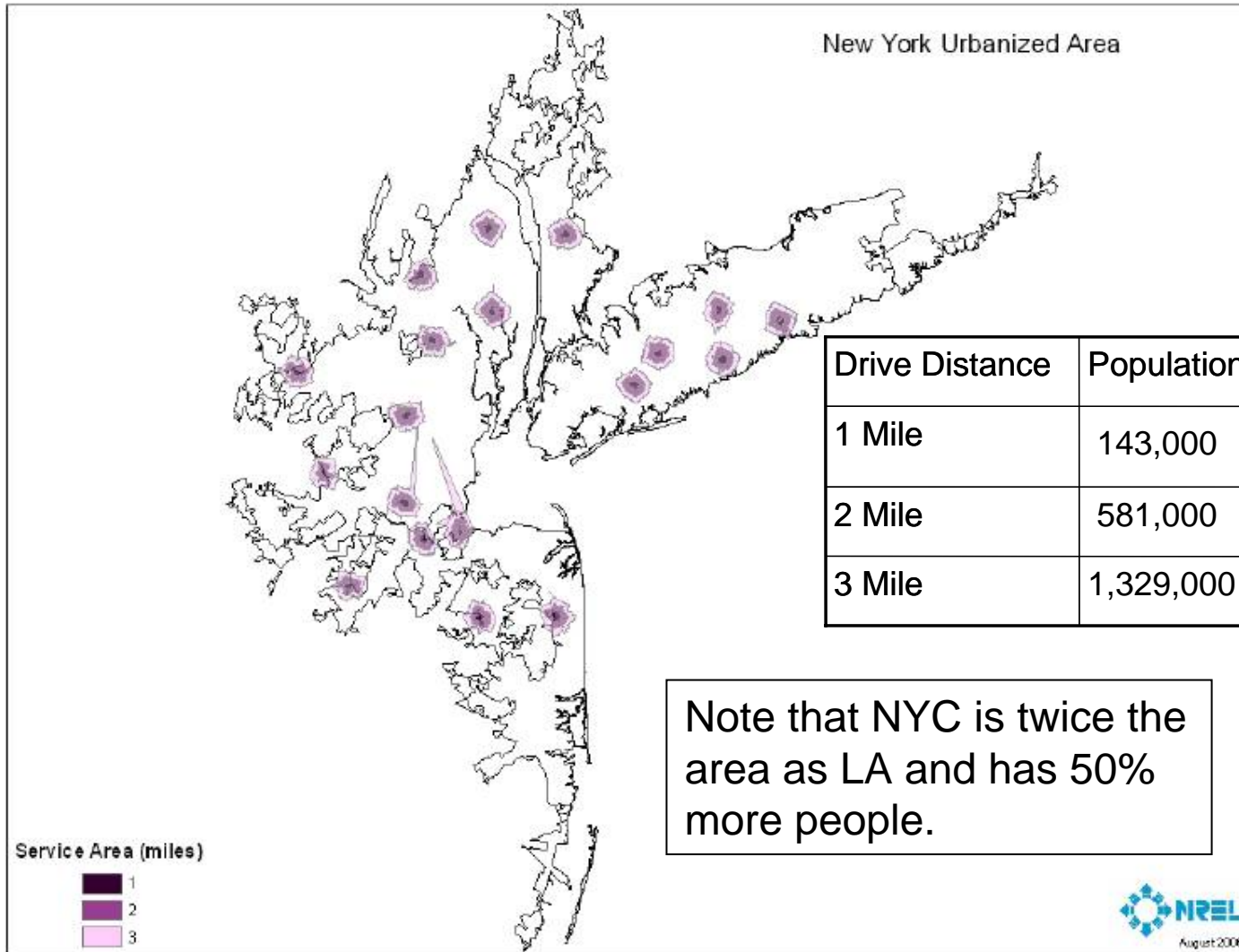


# LA Basin – 600 Stations

## ~20% of Existing Gasoline Stations



# Lighthouse Verification - New York City (19 Stations)

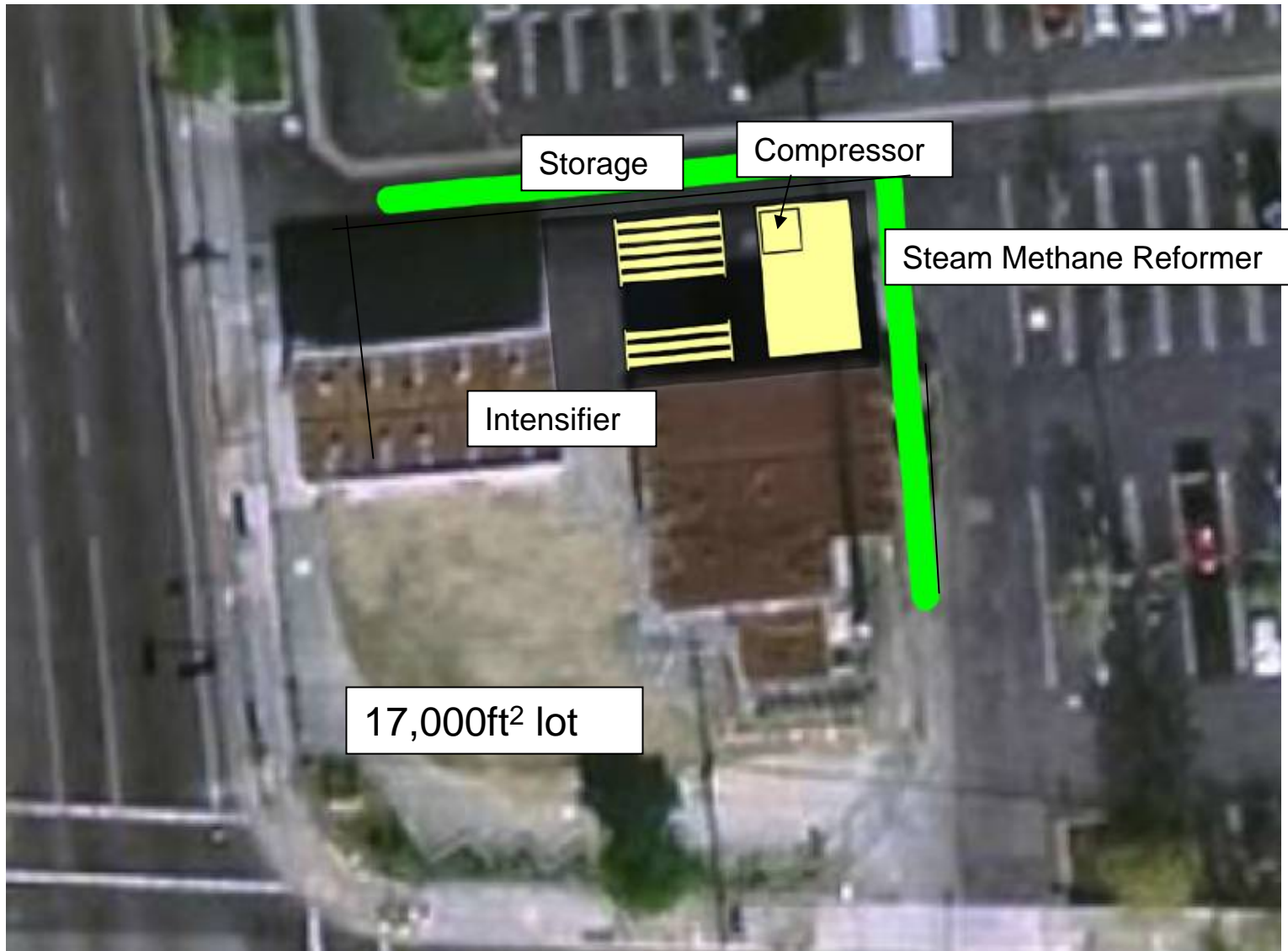


Drive Distance	Population	% Population (2000 Census LA Urbanized Area)
1 Mile	143,000	1%
2 Mile	581,000	3%
3 Mile	1,329,000	7%

Note that NYC is twice the area as LA and has 50% more people.



# 1500 kg/day SMR Footprint



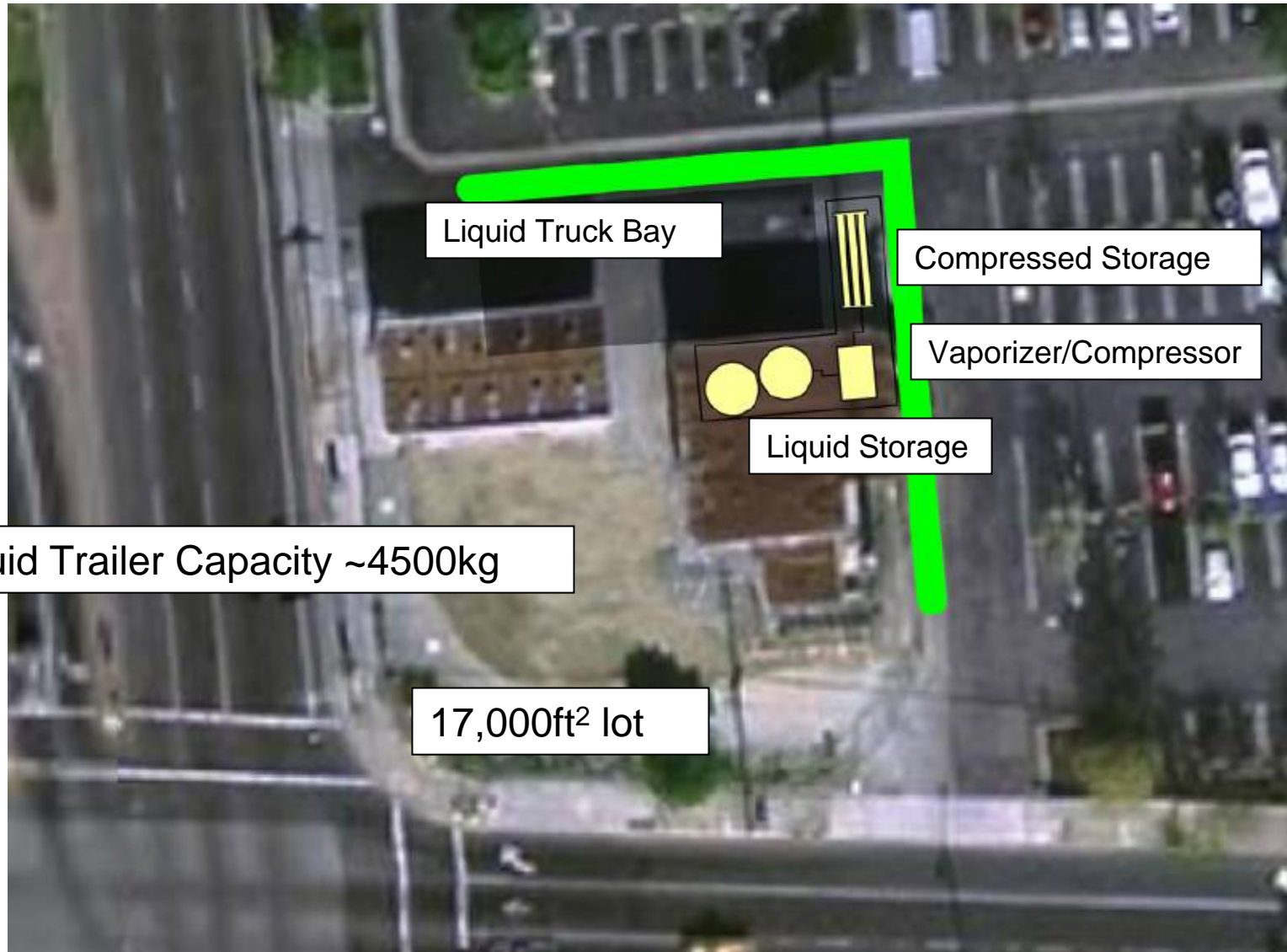
# Air Products SMR Design



# Steam Methane Reforming

- 1500 kg/day SMR footprint could be a problem at some sites, but is feasible at many.
- Permitting is an obstacle.
- Natural gas pipeline needs to be sized to 10,500,000 btu/hr. That requires a 3-4" NG pipe. A new feeder will be needed.
- Natural gas *distribution* system could be taxed if mass deployment of SMR is employed. Need to assess upstream effects.

# 1500 kg/day Liquid Delivery



Liquid Truck Bay

Compressed Storage

Vaporizer/Compressor

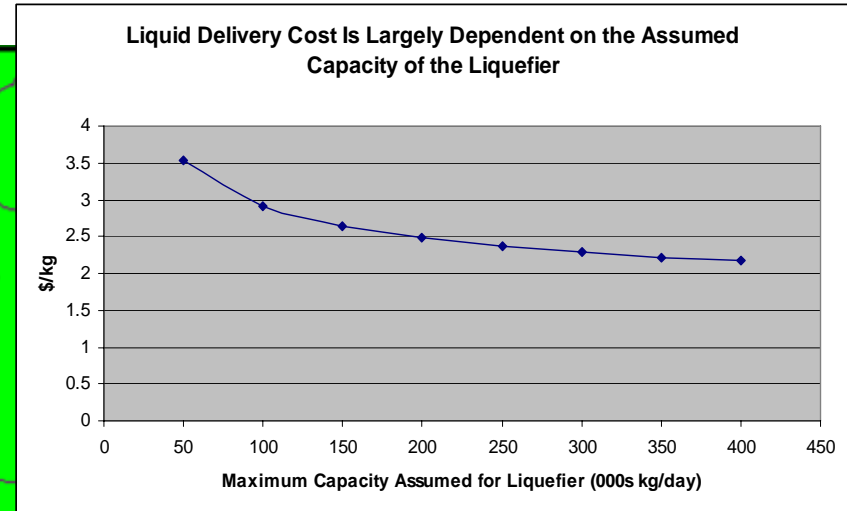
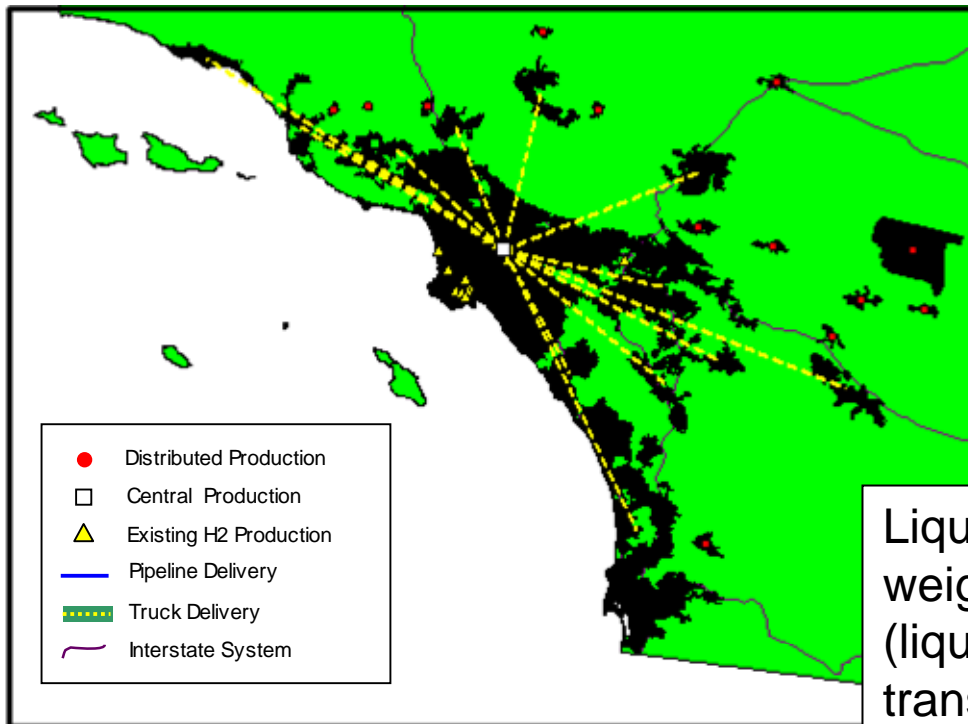
Liquid Storage

Liquid Trailer Capacity ~4500kg

17,000ft<sup>2</sup> lot



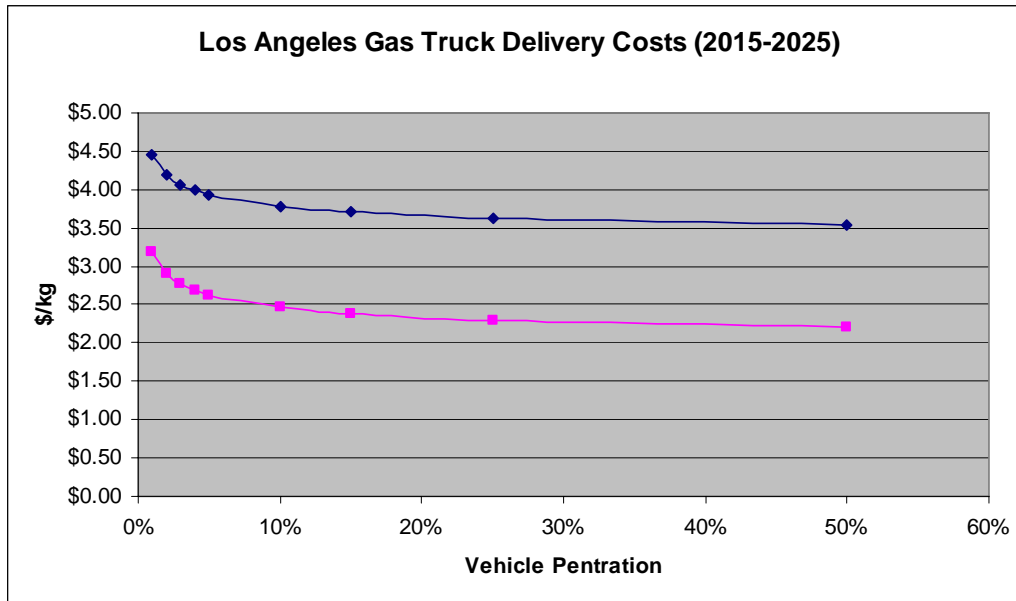
# Liquid Delivery Enables a Region to be More Easily Served from Central Production



Liquid delivery investment is heavily weighted at the source of production (liquefier and terminal). The cost of truck transportation is a relatively small cost (\$0.0011/kg.mi) enabling outlying communities to be served at little incremental cost.

BUT...liquefiers are expensive and VERY energy intensive.

# Gas Truck Delivery Costly in Near-Term Scenarios



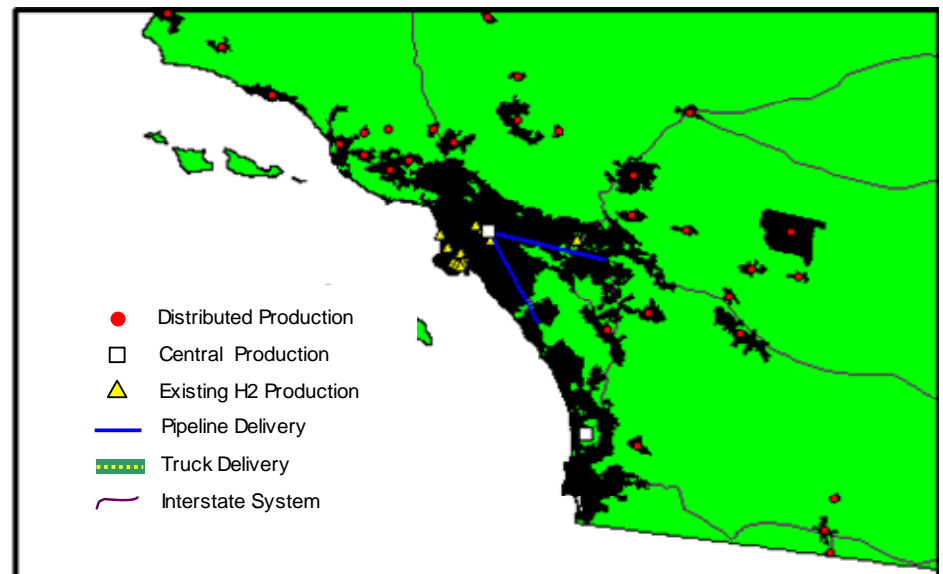
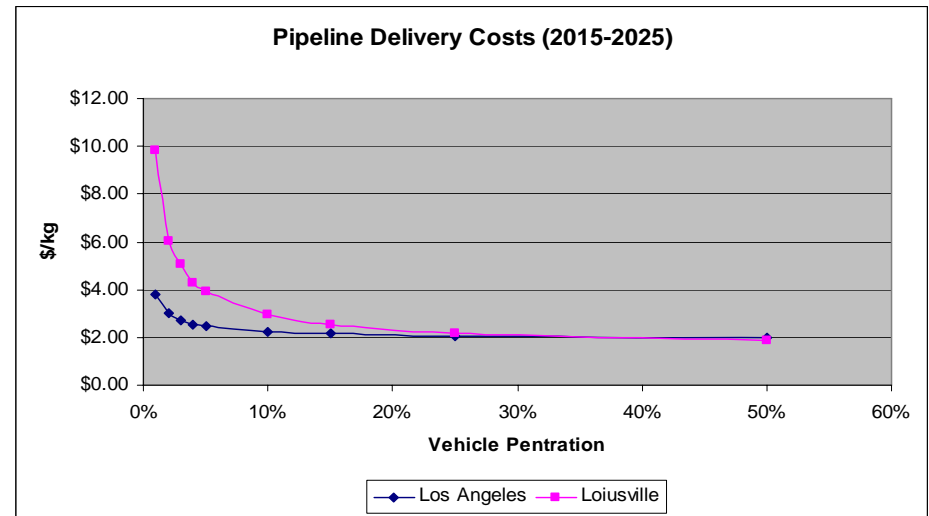
Low-Pressure Gas Trailer (7000 psi) holds ~650kg.

- Delivery to 1500 kg/day station requires two deliveries per day

- Potential for the long-term lies in the development of a high-capacity gas truck. If costs can be maintained at current capital, then gas truck delivery becomes competitive with liquid and pipelines.

# Pipeline Delivery Costs is Dependent on Total Demand and Urban Extent. Substantial Capital Cost Required

- Demand matter A LOT followed by the extent of the urban area.
  - Largest cities get scale economy first
  - Medium sized cities leverage nearby larger markets to reduce production costs, but they have to generate their own demand to drive down distribution costs.
  - Small communities are left to distributed production



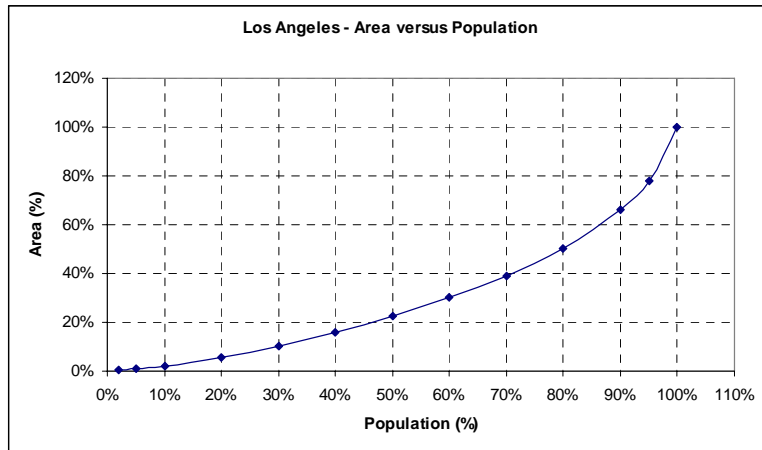
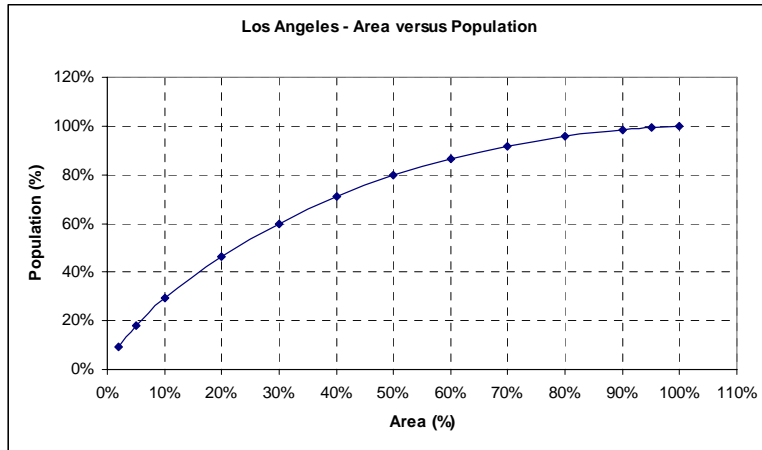
# Delivery Issues

- Investigate large scale deployment of distributed SMR on local natural gas distribution. Assess footprint issue on actual sites.
- Long term, liquid delivery has benefits (4500 kg/trailer). ability to serve large area, but cost is an issue. Liquefiers are the crux.
- Gas truck delivery for 1500 kg/day station requires a new trailer with high capacity (1100 kg?).
- Pipeline delivery may be (apparently) most cost effective, but substantial infrastructure commitment will need to be made and therefore considered a later option after 2025.



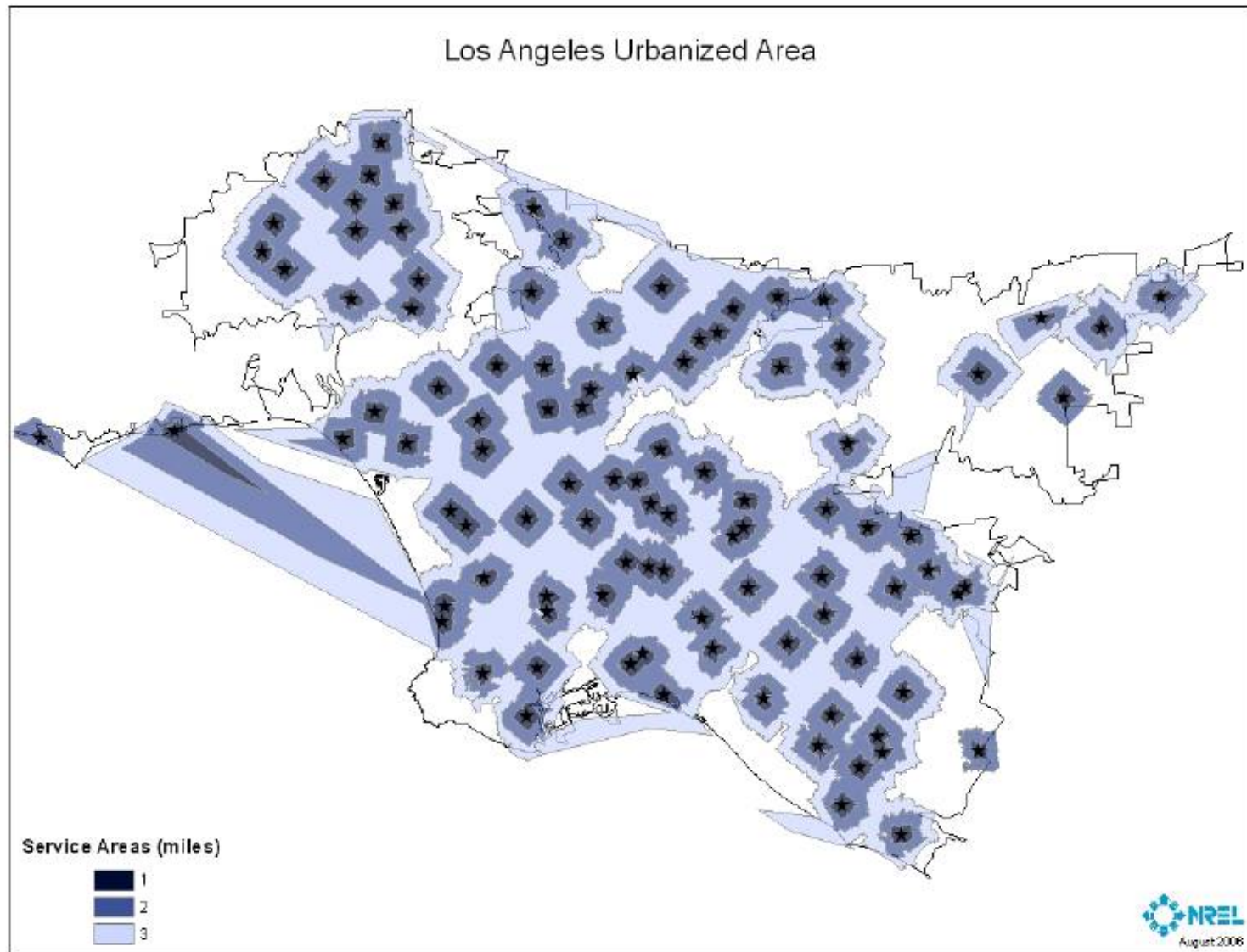
# Additional Slides

# Fewer Stations Work in LA Because LA is Very Dense



- In the top graph, 50% of the area contains 80% of the population
- In the bottom graph, 95% of the population lives in 80% of the area.
- You can quickly be near most of the population with a handful of well-placed stations

# Lighthouse Validation - 100 Stations w/ 1, 2 and 3-mile Service Areas



# Lighthouse Validation - 600 Stations w/ 2-mile Service Area

